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Development and Evaluation of Gluten-Free Shawarma Bread: A Nutritional Perspective

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Consuming gluten, a protein present in barley, wheat, and rye, can cause celiac disease, a chronic autoimmune condition that affects the small intestine and is activated in genetically susceptible individuals. The current study was designed to develop an optimal gluten-free alternative to shawarma bread with improved nutritional content and better sensory properties. For that purpose, five different types of bread were prepared: one control (T_0) and four experimental treatments (T_1, T_2, T_3, and T_4). Various ingredients, including chickpea flour, rice flour, pearl millet, guar gum, potato starch, brown rice flour, and sweet potato starch, were used to analyze which bread performed best in terms of nutritional content and overall acceptability. Nutritional analysis revealed significant variations in protein, moisture, fat, fiber, and ash content across the different formulations. Among the treatments, T_3, which included chickpea, brown rice, and millet flour, emerged as the most nutrient-dense, demonstrating the highest value of protein 25.82 %, fat 4.83 %, Ca 81.63, Fe 4.59, Mg 32.06, Zn 1.80, K 164.42, Na 260.7 in mg/100g as compared to control and other treatments. Water activity analysis further supported these findings, showing that T_3 had lower water activity of 0.87 as compared to control bread 0.90, suggesting improved stability and a longer shelf life. Despite these advantages, sensory evaluation revealed that the control (T_0) bread was the most preferred having score of 8.58 among participants for its taste and texture. T_3 got a minimum score for overall acceptability 7.61, T_4 (7.92), T_2 (27.82) ,T_1 (8.05). This preference is likely due to the control bread closely resembling the traditional shawarma bread that consumers are familiar with. While the experimental treatments offered a superior nutritional profile, their sensory attributes did not match the familiarity and appeal of the control bread. These findings highlight the potential of gluten-free shawarma bread as a nutritious alternative but also emphasize the challenge of achieving optimal consumer acceptance without compromising taste and texture. It was concluded that further research is needed to improve (by addition of natural bread improvers) the sensory profile of all gluten-free shawarma breads, specifically T_3, which one was the best among all in terms of its nutritional contents.
Keywords: Celiac, shawarma, bread, treatments, taste, texture, nutritional content, intolerance, sensory evaluation

INTRODUCTION

Shawarma bread, more commonly known as pita bread, is soft, round, and widely popular in the Middle East. For shawarma, falafel, and gyros, it serves as the base. The major purpose of this bread is to envelop meat, veggies, and sauce, rendering it suitable for wrapping or stuffing. Recent research indicates that about 1.95% of restaurants worldwide offer shawarma, underscoring its prominent role in the fast food and street food sectors. In nations such as Saudi Arabia, shawarma ranks as one of the most popular fast foods, with approximately 86.5 percent of the population regularly consuming it. Its appeal has also extended to Europe, Asia and North America where regional variations like gyros and tacos al pastor in Greece and Mexico have contributed to its global popularity (Amer *et al.*, 2022). The small intestine is affected by celiac disease, which is a chronic autoimmune disorder that affects individuals who are genetically vulnerable to the ailment. The ingestion of gluten, a protein that is found in wheat, barley, and rye, is the stimulus that sets off the condition. This immune response results in inflammation and damage to the lining of the intestine, which impairs the body's

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ability to absorb essential nutrients. Consequently, people with celiac disease often experience symptoms such as diarrhea, bloating, abdominal discomfort, and weight loss. Beyond digestive issues, the condition can also lead to other health complications, including anemia, osteoporosis, and neurological conditions such as migraines or neuropathy (Mauro *et al.*, 2023). Gluten-free bread has emerged as a vital dietary alternative for individuals with gluten-related disorders, including celiac disease, non-celiac gluten sensitivity, and wheat allergies. Gluten, a composite of storage proteins found in wheat, barley, and rye, plays a crucial role in providing the elasticity, structure, and chewiness characteristic of traditional bread. Developing gluten-free bread with desirable qualities poses significant challenges due to the absence of gluten, which imparts structure and elasticity to traditional bread. A study by Monteiro *et al.* (2021) analyzed various gluten-free bread formulations, highlighting the use of ingredients such as rice flour, maize flour, and potato starch, often combined with hydrocolloids like hydroxypropylmethylcellulose (HPMC) to enhance bread quality. The study emphasized the importance of specific volume as a quality indicator and noted that combinations of these ingredients effectively compensated for the lack of gluten. A review by Yano (2019) discussed the application of various hydrocolloids, such as xanthan gum and guar gum, to mimic the viscoelastic properties of gluten. These additives have been shown to enhance dough stability, gas retention, and overall bread quality. A qualitative study by Garnweidner-Holme et al. (2023) explored the experiences of individuals with celiac disease, revealing dissatisfaction with the taste and texture of commercially available gluten-free breads. It means best gluten free options should be developed that are best in terms of sensory analysis and nutritional content. This study aims to develop several types of gluten-free shawarma bread using a variety of ingredients, with the goal of creating a suitable meal for people with gluten intolerance. The research objectives include developing gluten-free shawarma breads in term of nutritional contents to meet the dietary needs of those with gluten sensitivity. To explore the alternative ingredients and examine their impact on the bread's structure and taste i.e. overall acceptability.

MATERIALS AND METHODS

***Sample preparation*:** Different cereals purchased from the local market of Multan, Pakistan were brought to DOFST BZU, Multan Pakistan. With the help of a laboratory-sized blender (National Model NB4020), the grains were reduced to a fine powder. After grinding, the powder was sifted using sieves with mesh sizes of two mm and one point five mm to ensure its fineness. Finally, the prepared flour was stored in polythene bags, labeled for future identification. For the preparation of gluten-free cereal flour, chickpea, rice, millet corn and guar gum, brown rice, potato starch, sweet potato starch was prepared according to treatment plan give in Table 1.

***Preparation of shawarma dough*:** The shawarma dough was made with the following ingredients: three grams of iodized salt, fifteen grams of maize oil, five grams of bread improver, eighteen grams of baker's quick-dry yeast, and two hundred and fifty milliliters of water. Using an electric mixer (Kenwood Dough Mixer) to incorporate all the components (except salt), the bread ingredients were blended using the straight dough method. We checked a tiny bit of dough to make sure the mixing was adequate after the 15 minutes of mixing was over. Curing the dough at 40 °C for 45-50 minutes while maintaining a particular relative humidity level followed mixing and shaping the dough. After pressing it down, the dough rested for 10 minutes in a pan or basin. Cooking the rolled dough for about a minute in a prepared frying pan was the next step. The dough was allowed to brown slightly in the pan without becoming charred. The shawarma bread that had been prepared was put in a bag and put in the fridge to be tested later.

Proximate analysis of shawarma bread

***Moisture determination*:** The moisture content of various types of shawarma flatbread was determined using the standard procedure outlined by the AACC (2000). Empty Petri dishes were first weighed, and then 5 grams of each sample were placed in them. The dishes were placed in an oven at 105 Degree Celsius for 24 hrs. After this period, the samples were weighed periodically until a fixed weight was reached. Following that, the formula for determining the moisture level was used:

Percentage Moisture = (Wet weight - Dry weight) / Wet weight × 100

***Determination of ash content*:** When organic materials are burned or smoked, the remaining residue is known as ash or minerals. The gluten-free shawarma breads' ash content was measured according to the AACC (2000). Once the smoke

Table 1. Treatment plan for development of shawarma bread.

Treatments	Fine flour %	Sweet potato starch	Millet %	Guar gum %	Chickpea %	Rice %	Potato Starch	Corn %	Brown Rice
T_0	100	0	0	0	0	0	0	0	0
T_1	0	0	40	2	10	43	0	5	0
T_2	0	0	40	2	10	30	13	5	0
T_3	0	0	40	2	10	21.5	0	5	21.5
T_4	0	13	40	2	10	40	0	5	0

became white and all the carbon had been burnt out, leaving just ash, five grams of each sample were heated in pre-weighed crucibles. After that, the ash was muffle-furnaced and heated to 550°C for as long as four hours, or until it became white. After that, a balance was used to measure the ash, and the reading was noted. We used this calculation to determine the ash content:

% of Ash = (Weight of Ash / Original weight of Sample) × 100

***Analysis of fat*:** The apparatus (Soxhlet) was used to determine the crude fat content in different gluten-free shawarma bread, following the procedure outlined by AACC (2000). Moisture-free samples weighing 5 grams each were placed in individual thimbles and positioned within the extraction tube of the apparatus. Hexane, with a volume of 250 milliliters, was used as the solvent to extract the crude fat from the samples. The samples underwent 10 washings over a period of 2 to 3 hrs, ensuring complete fat extraction. The extracted fat was then dried in a heated air oven until a fixed weight was achieved. The hexane was recovered for future use. The fat content was calculated using the following formula:

% Fat = (Residue weight / Sample weight) × 100

***Fiber determination*:** The AACC (2000) procedures were used to evaluate the crude fiber content in samples of non-gluten shawarma bread. Five grams of each sample was added to three 250 mL flasks, which were then acid-digested with 200 milliliters of a 1.25 percent H_2SO_4 solution. The contents of the flasks were heated on a hot plate to the boiling point and maintained for 30 minutes. After digestion, the contents were filtered through a muslin cloth to remove the defatted material. The remaining sample was transferred to a new flask containing 200 milliliters of a 1.25% sodium hydroxide solution for alkaline digestion.

The alkaline digestion process was conducted on a hot plate for 30 minutes, followed by filtering again through muslin fabric. The residue was then transferred to pre-weighed crucibles. These residues were dried in a hot air oven and subsequently charred using an open flame. The partially burned samples were then placed in a muffle furnace, where they were heated at 550°C to collect the ash, which ranged in color from grey to white. The formula that was used to calculate the fiber content is:

% Fiber = (Reduction of Weight after Ignition / Weight of the Original Sample) × 100

***Determination of proteins*:** We used the Kjeldahl technique, in accordance with the AACC-recommended protocols, to ascertain the protein concentration in a gluten-free shawarma bread sample. In a long-necked conical flask, a 5-gram sample was put. A digestion tablet and 25 milliliters of concentrated sulfuric acid were to the flask. Five milliliters of the pale green sample remained after the samples were heated on a plate for up to three hours to digest them. Once digestion was complete, the flask was taken off the fire and let to cool. After that, 250 mL of diluent was added to the sample.

Fifty milliliters of the diluted sample were moved to an additional flask with a long neck after digestion. To make distillation easier, 10 mL of a 40% sodium hydroxide solution was added. A solution of 4% boric acid, together with a few drops of methyl red indicator, was made in a beaker that held 25 milliliters. The nitrogen in the sample combined with the hydrogen in the sodium hydroxide during distillation to produce ammonia gas. In the boric acid solution, the ammonia gas was cooled and recovered as a liquid. Titration was performed on the ammonium sample extracted from the boric acid using a burette that had been filled with 0.1N sulfuric acid. The formula that was used to determine the nitrogen content is:

N% = (0.0014 × Volume of 0.1N H_2SO_4 × 75 mL) / (Weight of Original Sample × Volume of Diluted Sample Used) × 100

Protein content was determined by multiplying the nitrogen percentage by constant factor:

Protein % = Nitrogen % × Factor

***Minerals*:** We used Gul and Safdar's (2009) approach to find out how many minerals were in various kinds of shawarma bread. Atomic absorption spectrometry was used to identify minerals. The digestion flasks were filled with one milligram of bread powder for the sample. Each sample was mixed with 12 milliliters of nitric acid and let to sit at room temperature for the night. After that, 4 milliliters of per chloric acid were added to the mixture. The temperature was raised from 50 C to 250-300 C after an initial maintenance period. When white vapors emerged 75–80 minutes later, digestion was complete. The next step was to let the mixture cool before transferring it to a 100 ml flask and adding distill water to get the volume up to 100 ml. Various minerals, including iron, zinc, magnesium, sodium, calcium, and potassium, were extracted from the digested material and stored in marked plastic bottles. using an atomic absorption spectrophotometer for analysis.

***Water activity (aw)*:** The (aw) of samples of shawarma bread was measured using the method developed by Gallagher *et al.* (2005). The shawarmas water activity was measured with an aw meter (Aqua Lab).

Analysis of texture: Tong *et al.* (2010) provided the methodology that was used to examine the shawarma breads' textures. The bread's textural profile was evaluated using a EZ texture analyzer and has a five kg load cell. One day following baking, the bread was analyzed. The crosshead came with a cylindrical probe that measured 25 mm in diameter. For the purpose of the instrument test, the following parameters were defined: With a crosshead speed of 1 mm/s, the speed increased from 2.0 mm/s before the test to 10.0 mm/s after the test. At both the 1.00% and 50% distances, a 5.00-second rupture test is conducted. After that, the bread was sliced into 15 mm thick slices and then the ends were lopped off. We tested the bread for its firmness, springiness, and chewiness,

among other sensory attributes. We ran the tests three times and averaged the results.

***Sensory analysis of shawarma bread*:** The sensory features of the shawarma bread that were evaluated by the panel included its general acceptability, as well as its physical appearance, color, taste, texture, and fragrance. Members of the judging panel were distinguished faculty and students from BZU Multan's Food Science and Technology Department. We used a score-card method based on the nine-point hedonic scale to identify the shawarma's sensory qualities. A unique code letter was assigned to every shawarma bread sample. All of the quality attributes—physical appearance, color, taste, texture, smell, and general acceptability—were given a maximum score of nine. From 1 (strongly dislike) to 9 (very acceptable), the scale was used (Georges *et al.*, 2018).

***Statistical analysis*:** For the statistical analysis, Statistix (version 10) was used. To find out if there were any significant differences between the samples for any parameter, we used a one-way analysis of variance. Tukey's HSD test was employed to find particular differences between sample (Steel *et al.*, 1997).

RESULTS

***Proximate analysis of shawarma bread*:** Table 2 presents the proximate analysis of all treatments. The table delineates the nutritional content of gluten-free shawarma bread throughout five treatments (T_0 - T_4), emphasizing variations in protein, fiber, ash moisture, and fat concentrations. Treatment T_0, exhibiting a protein content of (15.19%) and the minimal ash content of 0.80%, indicates a more straightforward formulation with intermediate moisture levels (32.51%), likely yielding a product that is less wet and less nutritious. Treatment T_1 enhances this with (23.79%) protein, elevated moisture (34.93%), and increased fiber (3.25%), signifying a more robust formulation. Treatment T_2 presents a balanced composition, with (21.01%) protein and (33.24%) moisture, ensuring sufficient nourishment while sustaining moderate levels of fat and fiber.

***Mineral content of gluten free shawarma bread*:** Table 3 delineates the mineral analysis corresponding to the various interventions. This study examines the mineral content—specifically calcium, magnesium, iron, zinc, sodium and potassium—across five distinct formulations of shawarma (designated as T_0 to T_4), highlighting notable discrepancies in their mineral compositions. Treatment T_3 exhibits the greatest concentrations of Ca (79.90 mg), Mg (32.06 mg), Zn (1.80 mg), K (164.42 mg), and a relatively elevated Na content (260.7 mg), thereby establishing it as the most mineral-enriched option available. T_1 exhibits substantial mineral concentrations, notably in Ca (80.32 mg) and Mg (30.23 mg), alongside a considerable Zn content (1.79 mg). In contrast, T_0 exhibits the lowest mineral concentrations in various categories, specifically Ca (70.25 mg), Mg (28.24 mg), and K (151.16 mg), suggesting a more rudimentary formulation.

***AW (Water Activity) of shawarma breads*:** The water activity of all shawarma breads is presented in Table 4. The table displays the (aw) of shawarma bread over 5 treatments (T_0 to T_4), which substantially affect the storage life, microbiological status, and texture of the commodity.

Table 4. Water activity of gluten free shawarma breads (AW).

Treatment	
T_0	$0.90^{a} \pm 0.02$
T_1	$0.87^{b} \pm 0.05$
T_2	$0.87^{b} \pm 0.04$
T_3	$0.87^{b} \pm 0.06$
T_4	$0.89^{ab} \pm 0.03$

***Texture determination of gluten free shawarma bread*:** Table 5 presents figures of the texture of gluten-free shawarma bread throughout from (T_0 to T_4), emphasizing

Table 2. Proximate analysis of different gluten free shawarma breads.

Treatment	Protein %	Moisture %	Fat %	Fiber %	Ash%
T_0	$15.19^{d} \pm 0.82$	$32.51^{c} \pm 0.40$	$4.55^{c} \pm 0.01$	$2.88^{c} \pm 0.04$	$0.80^{d} \pm 0.02$
T_1	$23.79^{b} \pm 0.41$	$34.93^{a} \pm 0.02$	$4.82^{ab} \pm 0.04$	$3.25^{ab} \pm 0.04$	$1.06^{b} \pm 0.02$
T_2	$21.01^{c} \pm 0.74$	$33.24^{b} \pm 0.14$	$4.74^{ab} \pm 0.02$	$3.09^{b} \pm 0.02$	$0.94^{c} \pm 0.01$
T_3	$25.82^{a} \pm 0.32$	$35.42^{a} \pm 0.11$	$4.83^{a} \pm 0.02$	$3.34^{a} \pm 0.03$	$1.16^{a} \pm 0.01$
T_4	$21.88^{c} \pm 0.91$	$33.31^{b} \pm 0.16$	$4.73^{b} \pm 0.02$	$3.02^{bc} \pm 0.12$	$0.92^{c} \pm 0.01$

Table 3. Mineral analysis of Gluten Free Shawarma Bread (mg/100g).

Treatment	Ca	Fe	Mg	Zn	K	Na
T_0	$70.25^{c} \pm 0.30$	$4.25^{d} \pm 0.04$	$28.24^{c} \pm 0.26$	$1.21^{c} \pm 0.01$	$151.16^{d} \pm 1.03$	$253.66^{d} \pm 0.75$
T_1	$80.32^{b} \pm 0.30$	$4.59^{ab} \pm 0.01$	$30.23^{b} \pm 0.02$	$1.79^{ab} \pm 0.01$	$160.94^{b} \pm 1.00$	$259.00^{c} \pm 0.40$
T_2	$79.90^{b} \pm 0.11$	$4.48^{bc} \pm 0.06$	$26.77^{d} \pm 0.03$	$1.73^{b} \pm 0.01$	$156.00^{c} \pm 0.40$	$261.66^{ab} \pm 0.40$
T_3	$81.63^{a} \pm 0.60$	$4.59^{a} \pm 0.01$	$32.06^{a} \pm 0.04$	$1.80^{a} \pm 0.01$	$164.42^{a} \pm 0.83$	$260.70^{bc} \pm 0.25$
T_4	$79.22^{b} \pm 0.51$	$4.46^{c} \pm 0.01$	$28.11^{c} \pm 0.11$	$1.75^{ab} \pm 0.01$	$160.06^{b} \pm 1.24$	$262.80^{a} \pm 0.52$

springiness, hardness and chewiness, and Treatment T_3 showed the maximum hardness value of 3.46 N, signifying the most rigid texture, whilst T_0 presents the minimum hardness at 3.01 N, indicating a softer bread. Chewiness peaks at T_0 with a measurement of 4.26 kg/mm, signifying a firmer texture, whilst T_3 has the minimum chewiness at 3.88 kg/mm, denoting a softer, less chewy bread. In terms of springiness, T_0 exhibits the greatest value at 0.58 mm, indicating superior elasticity and the ability to revert to its original shape post-compression. T_3 has the lowest springiness of about 0.48 mm, indicating a less elastic texture.

Table 5. Texture analysis of gluten free shawarma bread.

Treatment	Hardness (N)	Chewiness (kg/mm)	Springiness (mm)
T_0	$3.01^{d} \pm 0.50$	$4.26^{a} \pm 0.23$	$0.58^{a} \pm 0.33$
T_1	$3.42^{ab} \pm 0.16$	$3.92^{bc} \pm 0.50$	$0.51^{bc} \pm 0.24$
T_2	$3.37^{bc} \pm 0.20$	$3.95^{b} \pm 0.80$	$0.53^{b} \pm 0.17$
T_3	$3.46^{a} \pm 0.35$	$3.88^{c} \pm 0.90$	$0.48^{c} \pm 0.52$
T_4	$3.34^{c} \pm 0.42$	$3.96^{b} \pm 1.00$	$0.50^{bc} \pm 0.30$

***Sensory analysis of gluten free shawarma bread*:** T0 achieved the highest sensory scores, excelling in overall acceptability (8.58), texture (9.61), color (9.16), and taste (9.11). T1 led in taste (9.41) and scent (8.5) but had lower texture (7.52), reducing its overall score (8.05). T2 showed balanced ratings, with strong color (8.31) and taste (8.98) but weaker fragrance (7.9) and texture (7.69). T3 had the lowest scores overall, with poor texture (7.31) and overall acceptability (7.61). T4 performed moderately, with reasonable color (8.21) and acceptability (7.92) but room for improvement in taste (8.39) and texture (7.64).

DISCUSSION

Treatment T_3 has the greatest values in all areas, including (25.82%) protein, (35.42%) moisture, (3.34%) fiber, and (1.16%) ash, indicating a superior formulation that optimizes both nutrition and texture. Treatment T_4 has (21.88%) protein and (33.31%) moisture, exhibiting a strong nutritional profile with well-balanced levels of fat, fiber, and ash. The treatments exhibit a purposeful range in constituent compositions, with T_3 providing the maximum nutritional value and T_0 embodying more basic makeup. The findings of the current study align with those of Azarbad *et al.* (2019), who said that the incorporation of millet enhances moisture and protein content in gluten-free bread.

Treatments T_2 and T_4 demonstrate intermediate mineral concentrations, with T_2 exhibiting the lowest Mg level at 26.77 mg, alongside a relatively high salt content of 261.66 mg. T_3 is recognized as the treatment exhibiting the highest mineral content, while T_0 is characterized by the least favorable mineral composition. The residual treatments demonstrate slight variations in the composition of essential minerals. This data elucidates the potential impact of different formulations on the nutritional profile of gluten-free shawarma bread, thereby influencing its health benefits and dietary advantages (Amer *et al.*, 2022). Control exhibits the greatest aw at 0.90, signifying more moisture availability that may improve softness but might also elevate the risk of microbial proliferation and reduce shelf life. (T_1), (T_2), and (T_3) have diminished water activity values of 0.87, indicating a more stable product with less moisture availability, hence prolonging storage life while preserving an appealing texture. (T_4), with a water activity of 0.89, occupies a middle ground, signifying a balance between moisture retention and microbiological stability. The variations indicate that T_0, exhibiting the highest water activity, may provide a softer texture, whereas T_1, T_2, and T_3, characterized by reduced water activity, are expected to possess enhanced shelf stability. The water activity levels among treatments underscore the necessity of regulating moisture to enhance both texture and shelf life in gluten-free bread compositions. The value of water activity was in contrast with the study of Kahlon *et al.* (2019) who reported water activity values ranging from 0.92 to 0.94 in their gluten-free flatbreads. These levels suggest that such products are prone to microbial growth, indicating the need for proper storage conditions to ensure safety and extend shelf life (Mauro *et al.*, 2023). The findings of texture demonstrate that T_0 provides the softest and most elastic texture, exhibiting the most chewiness, whilst T_3 is the firmest but less chewy and springy. These changes indicate distinct tactile experiences among the treatments, perhaps affecting customer preferences about the preferred bread texture. T_0's balanced attributes made it the most preferred treatment, while T_1's strong taste was offset by weak texture. T_2 showed potential with improvements needed in fragrance and texture. T3 was the least favorable, requiring significant modifications, while T_4 performed moderately but could benefit from enhanced taste and texture.

Table 6. Sensory analysis of gluten free shawarma bread.

Treatment	Color	Taste	Texture	Aroma	Overall acceptability
T_0	$9.16^{a} \pm 0.14$	$9.11^{b} \pm 0.10$	$9.61^{a} \pm 0.10$	$8.30^{b} \pm 0.10$	$8.58^{a} \pm 0.01$
T_1	$8.21^{b} \pm 0.10$	$9.41^{a} \pm 0.10$	$7.52^{b} \pm 0.01$	$8.50^{a} \pm 0.10$	$8.05^{b} \pm 0.04$
T_2	$8.31^{b} \pm 0.10$	$8.98^{b} \pm 0.10$	$7.69^{b} \pm 0.01$	$7.90^{c} \pm 0.01$	$7.82^{d} \pm 0.01$
T_3	$7.80^{c} \pm 0.01$	$8.12^{d} \pm 0.10$	$7.31^{c} \pm 0.10$	$7.94^{bc} \pm 0.01$	$7.61^{e} \pm 0.01$
T_4	$8.21^{b} \pm 0.10$	$8.39^{c} \pm 0.07$	$7.64^{b} \pm 0.01$	$7.73^{c} \pm 0.03$	$7.92^{c} \pm 0.01$

***Conclusion*:** This study provides a promising solution for individuals with gluten intolerance, particularly those diagnosed with celiac disease. The results show that gluten-free shawarma bread, made with alternative ingredients like chickpea flour, millet, and rice flour, offers significantly higher nutritional value in terms of protein and mineral content compared to the control bread, which was made using refined flour. These alternative ingredients boost the bread's nutritional profile, making it a healthier choice for those with dietary restrictions. Additionally, the gluten-free shawarma bread showed reduced water activity compared to traditional shawarma, which could contribute to a longer shelf life and better stability. In terms of texture, the gluten-free shawarma bread was slightly firmer and chewier than the control. Despite these textural differences, the control shawarma bread was still marginally more accepted, likely due to consumer familiarity with its traditional texture and flavor. Further research is needed to improve the sensory parameters of gluten free shawarma breads by adding natural bread modifiers. Nevertheless, the gluten-free version remains a nutritious and practical option for individuals with gluten sensitivity. To further promote the benefits of gluten-free shawarma bread, an awareness campaign should be introduced to educate the public on its nutritional advantages. Such initiatives could help increase the popularity of gluten-free alternatives, offering a healthier option not only for those with celiac disease or gluten intolerance but also for a broader audience seeking healthier bread choices.

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REFERENCES

Al-Faris, N. and M.O. Al-Jobair. 2017. Physico-chemical characteristics of pan and pita bread supplemented with the products of goat oggt. International Food Research Journal 24:1889-1896.

Amer, S.A., S.A. Alasmari, M.A. Amer, N. Al Aissa and E.E. Abd-Ellatif. 2022. Assessment of fast and junk food consumption and addiction among Saudi population. National Descriptive Study 2020. Current Research in Nutrition and Food Science Journal 10:19-30.

American Association of Cereal Chemists. Approved Methods Committee. 2000. Approved methods of the American association of cereal chemists. American Association of Cereal Chemists vol. 1.

Azarbad, H.R., M. Mazaheri Tehrani and H. Rashidi. 2019. Optimization of gluten-free bread formulation using sorghum, rice, and millet flour by D-optimal mixture design approach. Journal of Agricultural Science and Technology 21:101-115.

Gallagher, E., S. Kenny and E.K. Arendt. 2005. Impact of dairy protein powders on biscuit quality. European Food Research and Technology 221:237-243.

Garnweidner-Holme, L., M. Hellmann, C. Henriksen, E. Austad, S.I. Watters, L. Gaundal, and V.H. Telle-Hansen. 2023. Experiences with gluten-free bread: A qualitative study amongst people with coeliac disease participating in a randomized controlled trial. Foods 12:4338.

Georges, C., H. Daroub, I. Toufeili, H. Isma'eel and A. Olabi. 2018. Dough mixing properties and white pita bread sensory characteristics as affected by salt reduction. International Journal of Food Properties 21:2578-2589.

Gul, S. and M. Safdar. 2009. Proximate composition and mineral analysis of cinnamon. Pakistan Journal of Nutrition 8:1456-1460.

Kahlon, T.S., R.J. Avena-Bustillos, J.L. Brichta and A.K. Kahlon. 2019. High-protein nutritious flatbreads and an option for gluten-sensitive individuals. Foods 8:591.

Mauro, A., F. Casini, A. Talenti, C. Di Mari, A.R. Benincaso, G. Di Nardo and L. Bernardo. 2023. Celiac crisis as the life-threatening onset of celiac disease in children: A case report. Frontiers in Pediatrics 11:1163765.

Monteiro, J.S., P. Farage, R.P. Zandonadi, R.B. Botelho, L.D.L. de Oliveira, A. Raposo and W.M. Araújo. 2021. A systematic review on gluten-free bread formulations using specific volume as a quality indicator. Foods 10:614.

Steel, R.G.D., J.H. Torrie and D.A. Dicky. 1997. Principles and procedures of statistics: A biometrical approach (3rd ed.). McGraw-Hill, Inc. Book Co.

Tong, Q., X. Zhang, F. Wu, J. Tong, P. Zhang and J. Zhang. 2010. Effect of honey powder on dough rheology and bread quality. Food Research International 43:2284-2288.

Yano, H. 2019. Recent practical researches in the development of gluten-free breads. npj Science of Food 3:7; https://doi.org/10.1038/s41538-019-0040-1.